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Umbrella Terms as Mediators in the Governance of emerging Science and Technology

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Abstract

Umbrella terms like 'nanotechnology' and 'sustainability research' have emerged as part of the new regime of Strategic Science. As mediators between science and society they have a dual role. Their overall promise allows resources to be mobilised for new fields which can then be productive in their own right. At the same time, however, they also put pressure on these fields to take relevance considerations into account. The process of emergence and stabilisation of umbrella terms is outlined and traced in detail in the cases of nanotechnology and sustainability research. What we see is interesting de facto governance of science, as well as new forms of involvement of STS scholars.

1 Introduction

It is intriguing how new fields of science such as nanotechnology or sustainability research have emerged in recent decades with names that not only indicate a field of research but also promise major industrial transformation (in the case of nanotechnology) or claim to address daunting problems (in the case of sustainability research). What we see here is the intersection of two developments: a longer tradition of emerging new fields labelled to entail a particular scientific promise, as with physical chemistry in the late nineteenth century and colloid science in the early twentieth century, and a recent transformation of science in the direction of strategic science (Rip 2002), where long-term relevance to societal problems, hence a societal promise, is an integral part of how the science is done. The intersection of the two developments is visible if we look at how labels like 'nanotechnology' or 'sustainability research' are used and what they do to shape and hold together certain patterns in the de facto governance of science. In light of this function, we propose that the labels be called umbrella terms.

Our argument in this paper is that, in studying the mechanisms of governance that shape scientific development de facto, it is worthwhile taking a closer look at the organisational qualities of particular terms that can work to connect and mediate between a variety of activities and concerns across different fields of science, science policy and society – even without any explicit frameworks structuring those relations de jure. They link up and translate discursively patterned practices. Umbrella terms start out as a fragile proposal by means of which a variety of research areas and directions can be linked up with one other and, in a sense, 'covered' (which is where the metaphor of an umbrella comes in), with a view to relating them, as a whole, to certain societal concerns and policy issues. In this way they provide a semantic reference for negotiating certain packages of scientific search practices with societal and political concerns. Over time, umbrella terms and the packages they hold together may stabilise and become reinforced with research infrastructures and through the institutionalization of funding schemes.

This phenomenon of umbrella terms as mediators that enable the creation and functioning of packages of scientific research and policy and societal relevance indicates a new way in which science is being governed – de facto. This deserves to be explored, and not just in science policy studies with their occupational bias of prioritising policy. Science and technology studies (STS) have to contribute because of their tradition of studying the dynamics of scientific developments in context. Such a study of the governance of science is a relatively new venture for STS,[1] particularly when we consider how the study of umbrella terms, their emergence and possible stabilization, even when carried out merely in the form of a scholarly study, will have implications for the governance of science and the role played in it by STS scholars. The attention paid to a specific umbrella term will reinforce its status, even if the study actually deconstructs the ongoing processes.[2] This is unavoidable. It is also an

[1] There have been studies of governance of science by STS scholars all along, but they were considered to be at the margin of the field. This is changing now; see for example the shift in contents of the two STS Handbooks (Jasanoff et al. 1995 and Hackett et al. 2008). In 1995, all the classical themes of STS research were present, and one of the seven parts of the Handbook discussed science, technology and the State, with an emphasis on trends to be observed rather than governance questions. In 2008, two of the five parts were devoted to such issues, often explicitly discussing governance.

[2] The same comment can be made about STS scholars getting involved in the recent wave of technology assessment and ELSA studies of nanotechnology, and is being made, as one of us (AR) can testify.

indication that conducting STS in the real world requires further reflexivity.

We will explore the nature of the intersection of emerging scientific fields and strategic science, this being the location of the phenomenon of umbrella terms, in two steps. First, we will characterize the phenomenon of umbrella terms and locate it in present-day science within its respective contexts. Second, we will present two case studies with interesting differences, namely nanotechnology and sustainability research. While nanotechnology has become institutionalised as a field bearing this label, sustainability research has not, or at best has only done so to a partial extent, because different labels are competing to configure the science/policy link in particular ways. Furthermore, nanotechnology is about the opportunities and promises opened up by techno-scientific developments (with open and flexible links to societal and policy promises), while sustainability research (and its variants) are attempts to mobilise and position different scientific developments in relation to a socio-politically constructed global problem. Both are instances of the phenomenon of umbrella terms and how these function, broadly speaking, as mediators between science and science policy. In the concluding section we will reflect on the type of governance we can observe here, and also ask what our own role is in studying these developments.

2 Umbrella terms marking the intersection between strategic science and emerging scientific fields

Over the last three decades, the practices of scientific research, the institutions of science and their concrete contexts have all been changing, and there has been recognition of, and reflection on, these changes. There have been attempts to diagnose these changes, or certain aspects of them (Funtowicz/Ravetz 1993, Ziman 1994, Gibbons et al. 1994, Nowotny et al. 2001, Etzkowitz/Leydesdorff 2000, Bonaccorsi 2008, see also Bonaccorsi 2010, Lave/ Mirowski/Randall 2010). What is clear is that there is a general movement towards re-contextualisation of science in ongoing processes in wider areas of society (Nowotny et al. 2001, Markus et al. 2009), and that a new regime of Strategic Science has emerged after the opening up of the earlier regime in place since the Second World War (sometimes called Science, The Endless Frontier, after the title of the influential report of Vannevar Bush to the US President in 1945 (Bush 1945)). The opening up of this regime is already indicated in the influential 1971 Brooks Report to the OECD (OECD 1971), in which closer and more differentiated links between science and society were advocated, in contrast to the earlier regime in which 'science' is considered to be a unified whole. The next phase is indicated by the introduction of the notion of strategic research, linking basic research to societal problems and challenges. Irvine and Martin's (1984) characterisation of strategic research captures the nature of this link, indicating a new division of labour between the quest for excellence and for relevance:

Strategic research is
- basic research carried out with the expectation that it will produce a broad base of knowledge
- likely to form the background to the solution of recognised current or future practical problems.

The link is formulated in terms of expectations, but there are also new practices such as when research funding agencies started creating strategic research programmes,[3] and centres for excellent and relevant research were established inside or outside universi-

[3] So-called strategic research programmes already started to be drawn up and implemented in the 1970s (Rip 1990, Rip/ Hagendijk 1988).

ties from the 1980s, their continuing viability deriving from the emergence of markets of strategic research (Rip 2002). Also, priority setting became linked to foresight exercises. Such developments can be seen as creating institutionalised 'trading zones' between science and societal issues and their spokespersons.[4] Thus, there are reasons to speak of a new regime, a regime of Strategic Science. There are other developments as well, not directly related to strategic research, but compatible with it: the rechanneling of resources for scientific research through competitive project funding compared to block funding for universities and public research institutes, and the establishment of new audit and evaluation procedures.

In the 'trading zones' one sees packaging of social questions, opportunities, and scientific developments, which can be 'sold' to various audiences and which are often labelled so as to carry rhetorical force. An early example is the 'War on Cancer' programme in the USA in the 1970s (Rettig 1977). A recent example of such packaging is the discourse of 'Grand Challenges' in Europe and elsewhere (cf. EU: Lund Declaration, Horizon 2020). The way that the UK Research Councils have defined and outlined ten Grand Challenges (RCUK 2009) is illustrative of this, some in a technology-push or scientific-opportunity-driven mode, others in a society-pull or social-problem-

Box 1: *Two 'Grand Challenges' defined by Research Councils UK*

NanoScience through Engineering to Application	*Ageing: life-long health and wellbeing*
Nanotechnologies can revolutionize society. They offer the potential for disruptive step changes in electronic materials, optics, computing and in the application of physical and chemical understanding (in combination with biology) to generate novel and innovative self-assembled systems. The field is maturing rapidly, with a trend towards ever more complex, integrated nanosystems and structures. It is estimated that products incorporating nanotechnology will contribute US$1 trillion to the global economy by 2015, and that the UK has a 10 percent share of the current market. To focus the UK research effort we will work through a series of Grand Challenges. These will be developed in conjunction with researchers and users in areas of societal importance such as energy, environmental remediation, the digital economy and healthcare. An interdisciplinary, stage-gate approach spanning basic research through to application will be used. This will include studies on risk governance, economics and social implications	There is an unprecedented demographic change underway in the UK with the proportion of young people declining whilst that of older people is increasing. By 2051, 40 percent of the population will be over 50 and one in four over 65. There are considerable benefits to the UK of having an active and healthy older population with potential economic, social and health gains associated with healthy ageing and reducing dependency in later life. Ageing research is a longstanding priority area for the Research Councils. The Research Councils will develop a new interdisciplinary initiative (£486M, investment over the CSR period involving all seven Research Councils) which will provide substantial longer-term funding for new interdisciplinary centres targeting themes of healthy ageing and factors over the whole life course that may be major determinants of health and wellbeing in later life. Centres will be focused on specific research themes drawing on the interdisciplinary strengths of the Research Councils, such as Quality of Life, Physical Frailty and Ageing Brain.

[4] See Galison's (1997) discussion of 'trading zones'. He considered mutual translations between different disciplines and fields of research that would lead to the emergence of pidgins and creoles. In our discussion, the translations are between fields of science and science policy, and society as a further reference. The point about the emergence of pidgins and creoles remains applicable, up to the emergence of a 'blizzard of buzzwords' (Ziman, 1994) that is part of the regime of Strategic Science. The recontextualisation of science in society is genuine, however (Nowotny et al 2001, Rip 2010, Markus et al. 2009).

driven mode. In Box 1 we quote two of them in some detail, which will also allow us to refer to them in our further discussion.

In these examples, a short phrase summarises the thrust of the Grand Challenge. For the second Grand Challenge, the problem is often denoted as "the ageing society", a label that allows easy reference to a set of complex interrelated issues, while at the same time black-boxing them to some extent. Reference to "the ageing society" then becomes a justification to speak of "ageing research" rather than more disciplinary-oriented names like "biogerontology" (Miller 2009). The label "ageing research" can become a package in its own right, referring to assorted research with a shared relevance to "the ageing society". This fits the notion of strategic research, but is now positioned on the field level rather than as research projects. In the first Grand Challenge, a similar easy reference coupled with some black-boxing occurs through the label "nanotechnology", as in the opening sentence (where the plural is used). The reference is to a technoscientific field that definitely already exists as a funding category. Even so, it covers a wide range of items,[5] and for that reason can already be called an umbrella term.

Packaging of new scientific approaches with the help of labels has occurred in the history of science, for example 'physical chemistry' in the late 19th century (Dolby 1976) and molecular biology from the 1930s onward (Bartels 1984, Kohler 1976). An interesting further example is the rise of the notion of colloid science in the 1910s and 1920s, when the term was presented as indicating a fourth phase of matter (in addition to solid, fluid and gaseous) and the key to understanding the nature of living matter – and thus worthy of support and further exploitation (Ede 2007). Here, the audience for what starts as an umbrella term (because its scope is still unclear) is a scientifically concerned audience, and non-scientific audiences that put various issues of relevance upfront are involved only at one remove.

This continues to occur, but by now policy and other societal audiences are important as well. This implies that there is not only a struggle for recognition (and funding) of new fields within science, but also a struggle for legitimacy and resources in direct interaction with policy communities and a variety of social groups who are looking for opportunities to endorse and fund interesting research programmes. For society, this means a field of opportunities. For science, it often means space for new interdisciplinary approaches. And the promise of opportunities encapsulated in the umbrella term provides a protected space for such new approaches. The broad base of knowledge to be created through basic research, likely to form the background to the solution of future problems (cf. Irvine and Martin's definition of strategic research), is held in place by an umbrella term.

The phenomena we describe here have been noted and conceptualised before, in particular by the Starnberg-Bielefeld Group in their work on the so-called finalisation thesis. Their original ideas centred on the diagnosis that fields have to mature before relevance considerations can productively be included in scientific agendas, including "finalised" theory development. Their conceptualisation is based on how scientific paradigms, in the sense of Kuhn (1970), evolve, while this is just one

[5] In the example of nanotechnology, the fact that it covers a wide variety of scientific approaches and technological options is recognised. After noting that nanotechnology 'has become a handy shorthand label for several phenomena', Hodge et al., (2010: 6) discuss 'the immense range of technologies that fall under the nanotechnologies umbrella'. A further indication is how the European Commission and the UK Research Councils now speak of nanotechnologies in the plural.

aspect of inter-organisational fields of research. Their case studies, e.g. on environmental research and cancer research, did show more complex dynamics, as well as the role of umbrella terms (Böhme et al., 1978; Van den Daele et al., 1979, see also Schäfer 1983, and Rip 1997). What they did not consider was the phenomenon of translation zones and mediators, while this has now become a striking feature of science in our society. Umbrella terms have become mediators between the logics of scientific search and the logics of various societal and policy worlds, and are thus constitutive of new patterns of re-contextualised science and technology.

3 Umbrella terms and their dynamics

While an umbrella term is a part of discourse, its use in ongoing struggles (e.g. in building coalitions of scientists and policy actors) and its eventual wider acceptance in labelling organisations and programmes turns it into an institutional and practical reality. The inter-organisational field of research organisations, relevant government agencies, civil society organisations and representatives from domains of application acquires coherence and stability through reference to the umbrella term.[6] Thus, it is important to understand how umbrella terms acquire force as mediators between science and science policy and society.

Let us start by identifying examples. We mentioned ageing research and nanotechnology already. An earlier (and less grandiose) example is membrane science and technology since the 1970s, where the promises created a space that was filled in by dedicated R&D and gradually realised functionalities (Van Lente/ Rip 1998). There are other (sometimes partial) examples like synthetic biology or geo-engineering, both of which are definitely on the radar of science policy actors and funding agencies at the moment.

The umbrella terms can also start from the other side, when the entrance point is a newly articulated function to be fulfilled by different scientific and technological developments. Examples are 'targeted drug delivery' and 'personalised medicine', or 'the information superhighway' of the early 1990s, promoted by Al Gore among others. Kornelia Konrad has shown the power of this umbrella term in the way it led government agencies and city governments to invest in projects and, when these failed, to attribute it to contingencies so that they would invest in further projects rather than reconsider the promise (Konrad 2004, 2006). Security studies are an example where a number of different fields merged, or at least collaborated, under this umbrella term to address topics high on the political agenda. A further example is how sustainability (and sustainable development) has become a powerful reference in discourse, also of science and science governance: as something like an ecologically extended version of the 'common good' it can be invoked as a meta-grand challenge of world society. Relating activities and projects to it carries a diffuse but positive message, and can thus be used to mobilise resources. While sustainability itself is not an umbrella term in the specific sense of this paper, since it has not (yet) been established as a fixed term for talking about, supporting and negotiating a bundle of con-

[6] As societal concerns for relevance are sought to be embodied in the organization of the field, specific conceptions of society and its problems that underlie the notion of 'challenges' become inscribed into the emerging configuration of social relations under the umbrella. As it becomes an institutional reality, an umbrella term may thus 'co-produce' a particular form of science with a particular politically articulated form of society. On this point see, for example, Miller's (2004) analysis of interrelations between the constitution of a science of the global climate with the constitution of a new global political order.

crete research activities, it is an entrance point to study ongoing attempts at creating a science of sustainability where various candidate terms circulate (e.g. global change research, earth system science, sustainability science). We will discuss this further in our second case study.

The umbrella terms are mediators through which scientific promises and definitions of public problems travel and get entangled in constructions of 'relevant science'.[7] Thus, the umbrella term is not just a word or a phrase in a discourse, it is also, eventually, a conduit through which specific scientific opportunities and promises interact with specific societal and policy goals and interests, thus providing for their mutual shaping.

We will consider the process of emergence and stabilisation of umbrella terms, together with the inter-organisational fields that are formed, a bit further. An umbrella term emerges in a specific constellation of discourse, activities and incipient as well as more established institutionalisation. This is not just a matter of scientists packaging promises. Science policy makers scan the horizon for productive fields that can be linked to a 'public interest' and occasionally they initiate or catalyse the formation of fields which they expect to be important and for which they believe corresponding societal support can be mobilised. Increasingly, large corporations and business associations, non-governmental organisations and social movements also actively search for research practices that promise relevance to their concerns and engage with the framing of science-society relations.

There is a long tradition of opportunistic resource mobilisation by scientists, as well as "politicking" by spokespersons for science to assure symbolic resources for science (Rip 1990). A newly proposed umbrella term then is a way of packaging a proposal which offers an investment in scientific capacity: a 'sales proposal'. Some such sales proposals are more successful than others, and scientists will anticipate what is on the agenda in science policy and in society more generally, and adjust their proposal in terms of content, and definitely in terms of terminology. Intermediary actors such as funding agencies, when they identify with science rather than policy, follow similar tactics (this is visible in the Grand Challenges discourse of the UK Research Councils). Further tactics of resource mobilisation using visionary umbrella terms are visible to acquire funding on top of disciplinary funding structures, and/or to circumvent disciplinary funding structures for new, interdisciplinary research agendas. Occasionally, scientists refer to umbrella terms to offer their service directly to policy or society, thereby bypassing funding agencies.

If scientists offering their packages are seen as the supply side, the demand side consists of science policy makers and other sponsors of science wanting to provide funding (and other support) in an interesting and useful way. There will be reference to problem areas and societal challenges used to justify science policy and R&D program budgets, which can lead to further articulation of such problems and challenges. In this sense, science policy makers can also be seen as brokers between scientific supply and societal demand.[8] The

[7] Here, we use the term 'mediator' in a commonsensical way, but we can also refer to Latour and to Callon. In Actor-Network Theory, mediators are circulating entities with an inside that can be 'read' in and through their action. Callon (1991), who speaks of intermediaries in the sense of what Latour (2005) called mediators, gave examples of texts (inscriptions), technical artefacts, human bodies and money (and other promissories).

[8] What we are describing here is a central dynamic of priority setting, where supply and demand meet and become entangled in their further articulation in a variety of ways.

net effect is that a name or a phrase that works both ways, for policy as well as for science (or is made to work for both sides), helps to fill in the "trading zones" and acquires a life of its own: an umbrella term is born. [9]

There will be expectations, policy declarations, strategy meetings, platforms and other collective initiatives, programmes of research and new centres, dedicated intermediary organisations etc. Further actors will join, which will involve some controversy and struggling over the definition of boundaries – what is in, what is out, what is at the centre and what is only peripheral. This is an inter-organisational field, with epistemic components (one can speak of a new scientific field) as well as institutional, economic and socio-political components linked to problems, challenges and actual applications. There will also be public statements and media reporting, while scientists (and policy makers) will anticipate public reactions and civil society responses. Institutionalisation then leads to specialised organisations, including education and training programmes. The umbrella term represents and helps to stabilise the inter-organisational field while it functions as a conduit between scientific activities and society.

Implicit in this stylised description of umbrella term dynamics in context is a further element, namely how 'demand' and 'supply' for scientific research can clinch through shared reference to an umbrella term, and thus give the term force. In the case of nanotechnology, there was a very visible clinching event when the US National Nanotechnology Initiative was announced in 2000. In the case of sustainable development, there is increasing interest from institutions and sponsors. Various local clinchings occur under labels which use modifications of the root term 'sustainable' and a recent attempt was made to bring a diversity of research networks and sponsors together for a global programme entitled "Future Earth: Research for global sustainability" in which several of the currently advanced candidate terms appear in combination. This adds up to umbrella term dynamics, even without a single dominant clinching event that establishes a particular term as the reference for all ongoing attempts at configuring a science of sustainable development.[10]

4 Nanotechnology

Originally, the term 'nanotechnology' was used in an ad-hoc manner,[11] together with variants like 'nanoscale science' and 'nanoscale technologies'. Based on secondary literature and our own work and experience, we will trace its ascendancy as an umbrella term since the late 1990s, together with the emergence of an inter-organisational field represented by and sustaining the force of the umbrella term. We will then explore its dynamics, and end with a brief diagnosis of the present situation.

In the 1990s, there was the visionary use of the term nanotechnology by Eric Drexler and his Foresight Institute (Drexler 1986), and the practical and somewhat ad hoc use in descriptions of funding programmes (Van der Most,

[9] In the trading zone between 'relevance' and 'ongoing science', the authority to translate, in the process of emergence of umbrella terms and their eventual institutionalization, will thus allow power to be exerted, resources mobilised and research governed. Struggles about the definition and scope of the field, which are very visible in nanotechnology, are struggles to become authoritative.

[10] To be sure, the notion of a 'clinching event' is retrospective: whether an event is 'clinching' will not be clear at the time. Depending on further developments in the area of sustainability and science, one or another present event may turn out to have 'clinched' supply and demand.

[11] The term 'nanotechnology' was coined by Taniguchi (1974) for his own purposes. He is duly referenced, but his definition is not taken up.

2009). For many scientists, 'nanotechnology' was not important as a label. They were happy to do materials science or supra-molecular chemistry. The earlier funding programmes (since 1996 in Germany and Sweden, but already in 1994 in Switzerland) had specific topics related to existing scientific fields and areas of application. The UK's earlier 'National Initiative on Nanotechnology' (since 1986) led by an alliance between the government Department of Trade and Industry and the National Physical Laboratories was similarly specific, even though the general label was used. The two Nobel Prizes now listed as highlights in the development of nanotechnology, the 1986 Physics Prize for Scanning Tunnelling Microscopy (first publication in 1980) and the 1996 Chemistry Prize for Fullerenes (or buckyballs; first publications in 1985), were seen as important in their own right, and only later became an argument for the importance of nanotechnology.[12] Thus the term was available and used, but not as an umbrella term.

The promise of research at the nanoscale was recognised,[13] but there were no grand visions, except for Drexler's programme of 'molecular manufacturing'. This programme was actively promoted by his Foresight Institute, established in 1986. It organised meetings and conferences, gathered followers and generated general interest.[14] Richard Smalley, who became critical of Drexler's programme, still acknowledged how he had been inspired by the vision and the meetings he attended (Regis 1996: 275-278).

The landscape changed with the USA National Nanotechnology Initiative (NNI), announced in early 2000 by President Clinton. The NNI became a reference point for funding agencies and policy makers worldwide, and led to a 'funding race' (Rip 2011). It needed to justify itself in terms of promises, up to a third industrial revolution. Scientists started to refer more emphatically to nanotechnology in their funding proposals and presentations to the outside world. Research institutes and centres were renamed so as to include nanotechnology in their title (this was happening already, but NNI reinforced the trend). Journals appeared with nanotechnology (or the prefix nano) in

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[12] Neither the press release (http://nobelprize.org/nobel_prizes/physics/laureates/1986/press.html) nor the acceptance speech by Binnig and Rohrer mention nanotechnology or nanoscale science. They locate their work with respect to surface science. (They do mention, at the very end, that their scanning tunnelling microscope might be used to move atoms, and thus work as a 'Feynman machine"; Binnig/Rohrer 1993: 407.) Ten years later, the new laureates (as well as the press release) still focus on the science, now of fullerenes, but do make a reference to what happens 'at the nanotechnology front" (Kroto 2003: 76).

[13] For example, the very early UK National Initiative on Nanotechnology was an awareness-raising initiative, primarily in terms of the market potential of the new research results, but could not generate industrial interest. Apart from two small activities, all was quiet on the nano front in the UK until the end of the 1990s. (Van der Most 2009: 59). In 1996, the UK Parliamentary Office of Science and Technology published an overview of possible applications, under the title *Making it in Miniature: Nanotechnology, UK Science and it Applications*, but was content to note improvements in the miniaturisation of chips, in sensors, in surfaces, in diagnostic tools (ibid.: 6).

[14] Running ahead of the story: when the label nanotechnology became institutionalised (almost overnight, with the announcement of the US NNI), it became important to define its scope and establish who could legitimately refer to the label. Thus Drexler's futuristic project had to be excluded from what was now to be the mainstream. It became common to refer to molecular manufacturing as 'science fiction'. The 2003 (orchestrated) debate between Drexler and Smalley on the feasibility of molecular manufacturing has become iconic. Drexler countered the mainstream moves by calling this work superficial rather than deep nanotechnology, and so claimed 'real ' nanotechnology for himself. He lost the struggle, though (Rip/van Amerom, 2009).

their titles such as NanoLetters (since 2000) and the Journal of Nanoscience and Nanotechnology (since 2000).[15] Furthermore, meetings and platforms were organised to articulate strategies for nanotechnology R&D and innovation. The recent European Technology Platform Nanomedicine is a good example of such anticipatory coordination in terms of participants and topics (cf. also Rip 2012), while it is also clear that 'nanomedicine' is itself an umbrella term that covers very different developments, each with their own dynamics. Taking all this together, it is clear that the nascent inter-organisational field had solidified, together with its umbrella term 'nanotechnology'.

In recent years, nanotechnologists and policy makers have explicitly referred to nanotechnology as an umbrella term, though mostly to indicate the difficulties of defining nanotechnology and the variety of research areas and approaches encompassed under this heading. The European Commission started to use the plural: nanosciences and nanotechnologies. This is not just a recognition of variety. It is a response to the homogenising effect of using the term 'nanotechnology', and the problems this introduces in the societal and political debate about the risks and regulations of 'nanotechnology'. The halo effect of the term 'nanotechnology' continues to be exploited, however, for example in the recent move to emphasise 'green nanotechnology' as the real promise.

Looking back, one can enquire into how the launching of the US NNI became the key event. There was fertile soil for what we called a clinching between supply and demand sides. By the late 1990s one sees attempts at stock taking by funding agencies in a number of countries, sometimes induced by leading scientists (Van der Most 2009). In the USA, the National Science Foundation's adviser for nanotechnology, Mihael Roco, organised a meeting in 1997 to bring disparate activities in nanoscience and nanotechnology together across different agencies. This led to the establishment of an Interagency Working Group which met throughout 1998 and worked out a vision for what ultimately became the NNI (McCray 2005: 185-186). What is striking is how NNI brought a large number of government ministries and agencies, not known for their willingness to collaborate in science funding and science policy, together in a concerted effort.

Roco acted as an institutional entrepreneur, but was also well embedded in the emerging world of nanoscience. He created and spread visions of nanotechnology, referring to nanotechnology in general rather than some specific field; in particular, visions of a third industrial revolution enabled by nanotechnology, and of nanotechnology as the basis for converging technologies for human enhancement. The willingness of scientists and engineers to join in had to do with the prospect of increased funding, of course, but they could also share part of these visions about the promises of nanotechnology. At the 22 June 1999 meeting of the House of Representatives' Committee on Science, nanoscientist Smalley could say: 'There is a growing sense in the scientific and technical community (..) that we are about to enter a golden new era.' (McCray, 2005: 187).[16]

[15] Also dedicated journals such as the Journal of Nanoparticle Research (since 1999) and the Journal of Micro-Nano Mechatronics (since 2004). Grieneisen (2010) notes the exponential growth, since the end of the 1990s, and definitely since 2005, of journals devoted to nanotechnology. The first journal devoted exclusively to nano–scale science and technology, *Nanotechnology*, was launched by the Institute of Physics Publishing in July 1990. During the 1990s, only a few 'nano-journals' were launched; by 1998, the total number was 18. By 2010, 165 'nano-journals' had been launched, and 142 were still producing.

[16] He actually called for the use of nanotechnology as an umbrella term: "Nanotechnology, Smalley concluded, presented

The net effect outside the USA was that countries started to consider nanotechnology a priority, or reinvigorated what they were doing already. Often, it was an alliance between scientists who wanted to mobilise resources by referring to the example of NNI, and a small but influential number of policy makers who wanted to buy into nanotechnology as a major new priority. As we noted already, a funding race emerged in which countries (and regions like the European Union) compared their R&D expenditure on nanotechnology and argued that they should not lag behind. In spite of the reference to trillion dollar markets and a third industrial revolution (originally offered to help justify NNI, and then adopted in policy documents all over the world), major innovations enabled by nanotechnology were slow to arrive. There was no innovation race in nanotechnology, and after the first round of enthusiasm (in the early and mid 2000s), venture capitalists started to withdraw.[17] The recent move to 'green' nanotechnology can be seen as a response: a way to recapture societal and investors' interest.

After the first enthusiasm and somewhat indiscriminate funding, which allowed scientists (now called 'nanoscientists') to pursue their interests, the late 2000s saw attempts from policy makers, partly because of pressure from political actors, to get some value for money, i.e. making sure that the research that was funded would be relevant. The RCUK Grand Challenge Nanotechnology emphasising the route to applications (see Box 1) is one example.[18] In other words, 'nanotechnology' as a mediator between science, science policy and society moved from primarily offering a protected space for scientists to also work in the other direction, thus ensuring the relevance of publicly funded research.

One can ask whether nanotechnology, i.e. nanosciences and nanotechnologies, is also becoming a new scientific field. There is productive interdisciplinarity, centring on the technoscientific objects that are created and studied which then also create links to application/innovation.[19] Newly launched journals exploit the present visibility of nanotechnology (and some fail to survive, cf. Grienesen 2010). They create outlets for ongoing research, and thus contribute to the build-up and establishment of the field of nanosciences and nanotechnologies. The institutes and centres that use the nanotechnology label to present themselves are sites where the new scientific field can be nurtured. Such epistemic and institutional investments will remain in place when the nanotechnology hype has passed by.

5 Sustainability research

The term 'sustainable development' is a political construction which was de-

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a 'tremendously promising new future.' What was needed was someone bold enough to 'put a flag in the ground and say: 'Nanotechnology, this is where we are going to go …'". (McCray 2005: 187).

[17] Innovation did occur, in micro-nano-electronics and with nanomaterials and nanostructured surfaces for mundane but useful applications like coatings, dirt-repellent textiles, and reinforced tyres and tennis racquets.

[18] In the Netherlands, the NanoNed R&D Consortium (2003-2010), funded by public money, framed its research themes as basic research with some possible applications. Its successor, NanoNextNL, again funded by public money and some industrial contributions, had to frame a large part of its research in relation to energy, water, health and food. There was also political pressure to have 15% of the budget spent on research directly or indirectly related to possible risks of nanotechnology. For NanoNed, see http://www.nanoned.nl/. For its successor, NanoNextNL, see http://www.nanonextnl.nl/

[19] The notion of 'technoscientific objects' is the topic of a recent research project led by Alfred Nordmann and Bernadette Bensaude-Vincent. Available at: http://www.philosophie.tu-darmstadt.de/goto/goto/home/home.en.jsp.

vised in the context of the World Commission of Environment and Development (WCED 1987). The term marked an effort to unite concerns about the global environment with those about economic growth, and thus to overcome antagonistic positions between environmental movements and industry, as well as between North and South.[20] Since the1990s we have also seen references to sustainable development or sustainability in relation to science. There are efforts to position research activity in relation to what appeared to become an overarching societal and political concern. Attempts were made to articulate "sustainability science" or "sustainability research" as a new epistemic programme. A variety of scientific initiatives and sponsors established themselves on the force of 'sustainability' as an ideograph.[21] We will report on these efforts by drawing on documents and websites, and on our own observations from doing research in sustainability related programmes. We will give an account of how, in recent years, "sustainability science" started to compete with earlier terms like "global change research" or "earth system science". The trading zone is clearly visible. While no specific term has become dominant, there are dynamics that affect the configuration of research practices in relation to a wider field of societal concerns.[22]

The World Commission on Environment and Development (WCED 1987) had presented the term 'sustainability' to highlight an integrated view of issues of the environment and development and the need for coordinated policy strategies. Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own", and so required consideration of socio-economic as well as ecological dynamics. Inscribed into this view were the global nature of the challenge and a promise of "sustainable growth" as a solution to serve both the environment and the economy. As such, the term proved successful in the policy world. In 1992 it was endorsed as an overarching challenge and guiding principle of global public policy at the first "Earth Summit" in Rio de Janeiro. By the end of the 1990s sustainability had become a global buzzword, and an occasion to consider its translation into concrete action.[23]

[20] There is a history of the rise of terms like 'the environment' and 'environmental' in the 1970s, which functioned to some degree as an umbrella term under which funding programmes and university degrees took shape. Such use of the term 'the environment" continues, as in the title of Lubchenco's (1998) article: 'Entering the century of the environment'. Scientific unions rooted mainly in the natural sciences played a crucial role in articulating 'the environment' and its threat of deterioration or collapse. Prominent efforts were the 1972 Report to the Club of Rome on "the limits to growth" (Meadows et al. 1972) in connection with the first UN conference on the Environment in Stockholm in 1972, and its repercussions (e.g. establishment of UN Environment Programme and Environmental Ministries in many nation states).

[21] The notion of an ideograph was introduced by McGee (1980) to capture the function of terms like "the people" that are diffusely defined, allow various meanings to be projected onto them and are important to capture in a debate because of their positive rhetorical value. Rip (1997) showed how 'industry' and 'sustainability' functioned as ideographs in science policy discussions and practices. The same holds true for 'sustainable development' and is not limited to science policy occurrences.

[22] When using the term 'sustainability research' as the heading of this section of the paper, we might be seen as taking sides in the struggle. Since we needed a simple heading, we chose one which is relatively neutral as compared with the other possibilities.

[23] There is an ongoing battle over precise definitions and concrete actions which reflect a continued struggle for dominance between ecological and economic concerns, North and South, global and local – all those oppositions which 'sustainable development', as a political term, sought to overcome (Voß and Kemp 2006).

The surge of 'sustainable development' in policy discourse also mobilised researchers and science entrepreneurs. As a holistic challenge it called for new approaches to knowledge production. Sustainable development became translated into an epistemic challenge of studying interlinked dynamics of social and ecological systems and how they were to be governed. Scientists started various initiatives to fill the newly opened space with dedicated programmes that went beyond the established disciplines and their sponsoring arrangements. The International Human Dimensions Programme (IHDP) was set up in 1996 with a view to strengthening the social sciences as compared to WCRP and IGBP, two programmes of global change research that had already been running before sustainable development was introduced.[24] The "Resilience Alliance" built a network of international scientists geared towards the study of what they referred to as social-ecological systems.[25] Such initiatives positioned groups of researchers, and their specific approaches, as knowledge providers for sustainable development. Universities also produced joint declarations, presenting themselves as incubators of research for sustainable development and as hosts of education and training programmes.[26] The organising and positioning of research capacity was undergirded by an abundance of programmatic publications which sought to set out the epistemic agenda of sustainable development (e.g. Norgaard 1994; Schellnhuber / Wenzel 1998; Costanza et al. 1999; Clark et al. 2001; Gunderson/Holling 2002).

Two developments stand out: the declaration of a new 'sustainability science' in 2001 (Kates et al., 2001) and the formation of the "Earth System Science Partnership" by the global change research programmes.[27] Sustainability science made the stronger epistemic claim, and sought to enrol research practices developed through-

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[24] In 1979 the World Climate Research Programme (WCRP) was established (with sponsorship by the World Meteorological Organisation, WMO, and the International Council of Scientific Unions, ICSU), leading up to the "Toronto Conference on the Changing Atmosphere" in 1988 (paving the way for the Intergovernmental Panel on Climate Change, IPCC, and subsequent negotiations of a UN Convention on Climate Change). A broader focus on the global environment, and how it was changing, was adopted by the International Geosphere-Biosphere Programme (IGBP) which was established in 1986, also sponsored by ICSU.

[25] The Alliance was established in 1999, see www.resalliance.org

[26] For example the 1990 Talloires Declaration of University Presidents for a Sustainable Future; the 1993 Kyoto Declaration on Sustainable Development by the International Association of Universities (IAU). This continued: see for one example the July 2008, G8 University summit ("27 of the leading educational and research institutions in the G8 member nations") producing the "Sapporo Sustainability Declaration" (Available at: http://g8u-summit.jp/english/ssd/); Alliance for Global Sustainability (Av. at: http://globalsustainability.org/)

[27] In 2001, the international research programmes on global environmental change (WCRP, IGBP, IHDP plus a newly established one on biodiversity, Diversitas) got together under the umbrella of the Earth System Science Partnership (ESSP). Their "Amsterdam Declaration" stated that "(…) the business-as-usual way of dealing with the Earth System is not an option. It has to be replaced ¬ as soon as possible ¬ by deliberate strategies of good management that sustain the Earth's environment while meeting social and economic development objectives (…) A new system of global environmental science is required. This is beginning to evolve from complementary approaches of the international global change research programmes and needs strengthening and further development. It will draw strongly on the existing and expanding disciplinary base of global change science; integrate across disciplines, environment and development issues and the natural and social sciences; collaborate across national boundaries on the basis of shared and secure infrastructure; intensify efforts to enable the full involvement of developing country scientists; and employ the complementary strengths of nations and regions to build an efficient international system of global environmental science".

out the 1990s, to make a case for fundamentally new concepts and methodologies: "A new field of sustainability science is emerging that seeks to understand the fundamental character of interactions between nature and society […] Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information. [... It] differs to a considerable degree in structure, methods, and content from science as we know it. [...] In each phase of sustainability science research, novel schemes and techniques have to be used, extended, or invented […] Progress in sustainability science will require fostering problem-driven, interdisciplinary research; building capacity for this research; creating coherent systems of research planning, operational monitoring, assessment, and application; and providing reliable, long-term financial support" (Kates et al., 2001).

The term embodied a promise to develop and maintain links and interactions with the wider world, presenting itself as a bridge between the worlds of knowledge and action: "[Sustainability Science is] neither 'basic' nor 'applied' research but as a field defined by the problems it addresses rather than by the disciplines it employs; it serves the need for advancing both knowledge and action by creating a dynamic bridge between the two" (Clarke, 2007).

As a new candidate umbrella term, competing with 'global change research' or 'earth system science', sustainability science was launched by an international network of scholars,[28] which organised conferences, elaborated joint programmatic statements and liaised with science policy and funding agencies so that the term could achieve some consolidation. A scientific journal was established under this title in 2006.[29] The term was picked up by research ministries and funding agencies in several countries. In 2008 it became the title of a standalone section in the Proceedings of the US National Academy of Sciences (Clark 2007). Corporate sponsors also referred to the term in organising their relations with science.[30]

Independently of the efforts of such scientific entrepreneurs, sustainable development functioned as an increasingly forceful reference in the context of science policy. Sustainability-oriented research was part of an agenda to show that science could be activated in the service of broader societal challenges, not only competitiveness and economic growth. In 2002 the US National Research Council commissioned a study entitled 'Our common journey: A transition towards sustainability' (Board on Sustainable Devel-

28 Its stronghold is at the Program of Sustainability Science at Harvard University's Center for International Development. See: http://www.hks.harvard.edu/centers/cid/programs/sustsci (see also Board on Sus–tainable Development 2002).

29 *Sustainability Science*, established under the auspices of Springer Japan, introduces itself in the editorial as follows: "Sustainability Science provides a transdisciplinary platform for contributing to building sustainability science as a new academic discipline focusing on topics not addressed by conventional disciplines. As a problem-driven discipline, sustainability science is concerned with practical challenges such as those caused by climate change, habitat and biodiversity loss, and poverty. At the same time it investigates root causes of problems by uncovering new knowledge or combining current knowledge from more than one discipline in a holistic way to enhance understanding of sustainability."

30 cf. the 2010 International Conference on Sustainability Science (sponsored by business corporations and set up with a view to furthering links between 'world scientific leaders in Sustainability Science and representatives from industry and civil society', see http://icss2010.net/?p=industry-profiles), or the journal SAPIENS, which is sponsored by the transnational company Veolia to publish review articles and evidence-based opinions that integrate knowledge across disciplines.

opment 2002) which contained a promise to achieve sustainable development in two generations, provided sufficient resources would be made available for research (Raven 2002: 957). In various locales around the world, priority programmes were established under the responsibility of research agencies or governments.[31] Special centres were also established, such as the Japan Integrated Research System for Sustainability Science (2005), the Stockholm Resilience Centre (2007), and the Institute for Advanced Sustainability Studies in Potsdam (2009). Such programmes, centres and platforms provided niches in which sustainability research was nurtured as parts of broader networks and discourses. This is how research became institutionalised to a certain degree, in a rather fragmented manner, and came to depend on coalitions between certain groups of scientists and entrepreneurial sponsors, which allowed established institutions of research funding and science policy profiling to be locally bypassed against the mainstream of economic-growth oriented R&D. There is a grey zone between such dedicated efforts and the relabeling of ongoing research as being related to sustainability for the sole purpose of increasing eligibility for funding. Furthermore, the epistemic status of sustainability research was contested, especially with respect to its interdisciplinary character and its orientation towards politically defined problems.[32]

On the policy side, the framing of sustainable development as a global problem entailed difficulties for translation into support of research. In contrast to political support for 'nanotechnology' or research on the 'ageing society', the sponsoring of scientific activities by reference to sustainability invokes a global public good, not a national or regional one. It thus implies a problem that requires collective action in the area of national or regional science policy making and research funding. This is recognised, and attempts have been made to set up international agreements of cooperation. An International Group of Funding Agencies for Global Change Research (IGFA) has met regularly since the beginning of the 1990s to coordinate support for international programmes of Global Change Research.

New efforts to mediate between science and policy with a view to achieving global sustainability were made in the run-up to another 'Earth Summit' in 2012, again held in Rio de Janeiro. The official objective of "Rio+20", namely to "secure renewed political commitment for sustainable development",[33] provided a reason to push fur-

[31] At the European Union, DG Research (now DG Research and Innovation) hosts a platform for 'sustainability science" and launched an initiative entitled Research and Development for Sustainable Development (RD4SD), which included a Conference on 'Sustainable development: a challenge for European research" in 2009. The German Research Foundation (DFG) had a "Schwerpunktprogramm Mensch und globale Umweltveränderung" (http://www4.psychologie.uni-freiburg.de/umwelt-spp/welcome.html), the German Federal Ministry for Education and Research (BMBF) set up a funding initiative for "social-ecological research" (http://www.sozial-oekologische-forschung.org/) in 2000, and later established 'research for sustainable development' (Fona) as an umbrella label for a variety of research lines that were brought together on a common 'platform" (http://www.fona.de/).

[32] There is a tension between natural and social sciences, cf. "Sustainability science has a good deal to say about how we can logically approach the challenges that await us, but the social dimensions of our relationships are also of fundamental importance" (Leshner 2002: 957). There are also discussions about the methods and quality criteria of sustainability science as a normatively oriented endeavour aspiring to inclusiveness with regard to a diversity of knowledge that is to be integrated (e.g. Thompson Klein et al. 2001; Nölting et al. 2004; Bergmann et al. 2005; Pohl/ Hirsch-Hadorn 2007).

[33] http://www.uncsd2012.org/objectiveandthemes.html

ther towards the establishment of an integrated knowledge base. In 2006, ICSU had already started a joint review of global environmental change programmes with the funders in IGFA.[34] This led to an Earth System visioning process, now together with the International Social Science Council (ISSC), for constructing the agenda of a disciplinary and regionally integrated science for sustainable development (ICSU 2002, 2005; ISSC 2012).[35] Various funding agencies articulated their demands and established a group of "high-level representatives", the Belmont Forum, in order to pursue negotiations with representatives of science.[36] In 2010 the Belmont Forum, together with representatives of ICSU and ISSC, and of UNEP, UNESCO and the United Nations University, met to negotiate a 10-year joint initiative of science policy to "[p]rovide earth system research for sustainable development". The initiative was finally launched under the label "Future Earth – research for global sustainability" at the Rio+20 conference.[37]

What we see is convergence towards an inter-organisational field while there is still a struggle over the preferred umbrella term. There is deliberate negotiation about how scientific supply and societal demand can be clinched, as well as about how various candidate umbrella terms could be combined to form a phrase that might function as an umbrella. Whether this was just a matter of tactics, or was based on dedicated reflection, is not clear.

6 Conclusion and reflections

We identified a phenomenon in the worlds of science, science policy and general politics: umbrella terms and their concomitant inter-organisational

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34 It was concluded that "[t]here is a clear need for an internationally coordinated and holistic approach to Earth system science that integrates natural and social sciences from regional to the global scale" (ICSU-IGFA, 2008), and further that there is a "need for a unified strategic framework (…) to deepen understanding (…), deliver solutions".

35 ICSU co-sponsored all programmes of global environmental change research as well as coordinated efforts on "joint projects on global sustainability" (in Water, Food, Carbon, Human Health) under the Earth System Science Partnership. In promoting IHDP since 1996, the Council has undertaken targeted efforts to give a role to the social sciences (see ISSC 2012). The Earth System visioning (2009-2011) articulated research questions as "five grand challenges" from the point of view of science: "observing, forecasting, thresholds, responding, innovating".

36 The Belmont Forum, established in 2009 out of IGFA: "a high level group of the world's major and emerging funders of global environmental change research and international science councils [which] acts as a Council of Principals for the broader network of global change research funding agencies, IGFA [so] aligning international resources" constitutes a further attempt to create an inter-organisational field. "[It] developed a collective 'funders' vision of the priorities for global environmental change research" (Belmont Forum 2011). Cognitive challenges are identified, linked with action perspectives – and a candidate umbrella term: "recognition that the understanding of the environment and human society as an interconnected system, provided by Earth System research in recent decades [..] to provide knowledge for action and adaptation to environmental change [..] remove critical barriers to sustainability [..] integrated into a seamless, global Earth System Analysis and Prediction System (ESAPS), which will provide decision-makers with a holistic decision support framework" (ibid.).

37 The declared aim of 'Future Earth' is "reorganizing the entire global environmental change research structure, and the way of doing research" with a view to "integrating the understanding of how the Earth system works to finding solutions for a transition to global sustainability". It seeks to build on and integrate earlier activities "and enhance (…) global environmental change programmes and projects", but looking towards "new solution focused projects". The approach is one of "co-designing and co-producing research agendas and knowledge" by "policy makers, funders, academics, business and industry, and other sectors of civil society" (ICSU 2012).

fields, which mediate between ongoing scientific research and policy requirements for societal relevance. We then presented two cases, nanotechnology and sustainability research, which qualified as established and emerging umbrella terms, respectively, and which allowed us to delve into actual complexities. What did we learn? We can compare and contrast the two cases. We can also step back and reflect on what we saw happening, and what this tells us about the dialectics of promising science and technology as modulated by umbrella terms. This will set the scene for a brief discussion of *de facto* governance of science through umbrella terms, and the role of STS scholars in such *de facto* governance.

There are two important differences between the two cases. First, nanotechnology offers open-ended promises about what it might enable us to do, while sustainability science and global change research and earth system science reason back from global challenges to what scientific research should contribute. While the histories are different, the process is the same, with the two cases being at different phases: there are struggles linked to potential umbrella terms, a dominant term emerges and becomes established, at least for some time, as a conduit which allows protection of ongoing research as well orientation towards relevance to societal problems and challenges.

One can zoom in and see an interesting parallel between the group of scientists that is pushing 'sustainability science' and the Drexler group that is pushing nanotechnology as molecular manufacturing. Both have visions about what a 'new kind of science' can achieve, and both get a hearing. In the case of nanotechnology, the clinching of supply and demand came from another direction thanks to the US National Nanotechnology Initiative and its international repercussions, which overtook (and eclipsed) the Drexlerian vision. In the case of sustainability science, the ambitions may also be too high, but the sustainability scientists (to coin a term in much the same way that the term nanoscientists emerged) appear to be well embedded in established international organisations and networks. They may make some progress in the coming years, even if more technocratic versions have to be accommodated in ongoing negotiations with disciplinary scientists and policy makers, as is visible in complementary references to 'Earth System Science'.

A hard-nosed question, for both cases, is whether umbrella terms merely reflect the latest fashion in science funding and sponsorship, and will be washed away when the next wave arrives. The umbrella term may disappear, but there will be lasting structural changes linked to inter-organisational fields that emerged and solidified. In the meantime, actors in the worlds of science and science policy will use actual and potential umbrella terms for their own purposes. But once an umbrella term is in place, i.e. after the clinching of supply and demand and some institutionalisation, it cannot be escaped (or only at a cost). So in addition to indicating a new pattern of science governance which combines relevance considerations and some autonomy of research (as befits the regime of Strategic Science), the term itself has a governance effect. Umbrella terms, once established, are a de facto governance technology, and actors realise this and struggle over the term and its articulation.[38] The eventual result of an umbrella term becoming forceful is the

[38] This is part of a larger problem which one of us has articulated for the case of policy instruments as a governance technology: on the knowledge production side there is linking and packaging to create an input in policy (such as the provision of solutions) which then somehow functions in the making and implementation of policy (such as the treatment of public problems) (Voß 2007b, 2007a).

outcome, at a collective level, of many actions and interactions.

Thus there are two ways in which umbrella terms are a governance technology: they constitute an arena for struggles about definitions, access/exclusion and resources;[39] and their eventual black-boxed use has effects precisely because the detailed struggles that went into them are eclipsed.

Two final reflections are in order. Firstly, about the governance of science: While use of the term governance helps us to move away from an exclusive focus on government and its attempts at top-down steering, there is still a top-down bias in many studies in the sense that government steering is the standard which now needs to be modified. What we have shown is that there are elements of science governance in ongoing developments, exemplified in this paper by the emergence and stabilisation of umbrella terms mediating between science, science policy and society. Governance then shifts from attempts to realise policy goals as such to considerations about what is happening anyway and how this is modulated in reference to public interests.

The second reflection concerns the role of STS scholars. Both authors were and are active in the fields we used as case studies in this article, and even benefited from the new resource flows by having their own research projects funded. We had discussions with actors in the field, and sometimes explicitly (albeit modestly) intervened.[40] The present article constitutes a further step: it opened up the black box of umbrella term dynamics – a typical STS approach – and if it were to be read by actors in the field, they could take it up as a move in their struggles. However, we are also contributing to the existence of the field because talking about 'nanotechnology' or 'sustainability science' helps make them become more real. This is unavoidable, and one should not retract from it, [41] but try to understand what is happening and position oneself reflexively.

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[39] A similar point is made for nanotechnology by Wullweber (2008), using Laclau's notion of 'empty signifiers' (Laclau 1996).

[40] As we did in our projects of constructive technology assessment of nanotechnology, we have conceptualised this as "insertion", see Rip and Robinson (forthcoming).

[41] This is an argument against Latour's position: 'The task of defining and ordering the social should be left to the actors themselves, not taken up by the analyst.' 'ANT simply doesn't take as its job to stabilize the social on behalf of the people it studies; such a duty is to be left entirely to the 'actors themselves' (…)' (Latour 2005: 23, 30).

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